BOEM Pacific Region: Ongoing Study

Title	Assessing and Advancing Individual Matching Accuracy of Photographed Gray Whales Using Artificial Intelligence (PR-20-GRY and PR-21-GRY)
Administered by	Pacific OCS Region
BOEM Contact(s)	Desray Reeb (desray.reeb@boem.gov)
Conducting Organization(s)	Wild Me
Total BOEM Cost	$25,000 (Phase I: $10,000; Phase II: $15,000)
Performance Period	FY 2020–2022
Final Report Due	August 25, 2021 (Phase I report) and August 2022 (Phase II report)
Date Revised	August 26, 2021
PICOC Summary	
Problem	Intermingling occurs between the highly endangered western North Pacific gray whale, and the eastern North Pacific populations, as well as the Pacific Coast Feeding Group. Short-term, long-term, and cumulative effects analyses require an accurate understanding of the distribution, status, and sensitivities of species anticipated to be exposed to anthropogenic impacts. Discerning between highly endangered and other gray whale stocks needs to be better understood in order to resolve this problem.
Intervention	Incorporate machine learning to use extant photographic data to better understand marine mammal populations in the vicinity of energy and mineral development operations.
Comparison	These efforts will advance existing efforts being undertaken by NOAA and the Cascadia Research Collective by adding a third algorithm to assess the feasibility of AI to match photographed gray whale lateral ridges and then increasing the accuracy of these algorithms.
Outcome	Results of these efforts will advance and suggest avenues forward in scaling gray whale matching using computer video-machine learning and artificial intelligence.
Context	Pacific Region

BOEM Information Need(s): Under NEPA, the MMPA, and ESA, BOEM is required to assess the impacts of permitted activities on protected species. Since intermingling occurs between the highly endangered western North Pacific gray whale and the eastern population, as well as the Pacific Coast Feeding Group (PCFG), it is important to be able to distinguish between these populations and better understand their distribution, status, and sensitivities related to anthropogenic impacts.

Background: Gray whales (*Eschrichtius robustus*) are unique to the North Pacific Ocean. Reproductive success in the highly endangered western North Pacific gray whale population (approximately 200 individuals) was found to have been impacted by the co-occurrence of seismic surveys and on-land pile driving (IUCN 2009). Intermingling between the highly endangered western North Pacific population and the eastern North Pacific (ENP) Population, as well as the recently identified PCFG of gray whales

(Calambokidis et al. 2010), a potentially demographically distinct stock (Frasier et al. 2011), does occur (Lagerquist et al. 2018; Mate et al. 2015) and a genetic study suggests that individuals from different feeding areas may interbreed (Lang et al. 2014). Short-term, long-term, and cumulative effects analyses require an accurate understanding of the distribution, status, and sensitivities of species anticipated to be exposed to anthropogenic impacts.

The Bureau of Ocean Energy Management (BOEM) is engaged in several studies which incorporate machine learning to better understand marine mammal populations in the vicinity of energy and mineral development operations. These studies require the ability to ingest and analyze vast quantities of mark-recapture photo-identification data efficiently. This project consists of two phases, the first phase, entitled 'Feasibility Analysis: Using Artificial Intelligence to Match Photographed Lateral Ridges of Gray Whales', and the second phase, entitled, 'Phase II of the Gray Whale Study: Advancing Individual Matching Accuracy of Photographed Gray Whales Using Artificial Intelligence, will partner with the National Oceanic and Atmospheric Administration's National Marine Fisheries Service's Southwest Fisheries Science Center and the Cascadia Research Collective to build upon and advance these existing efforts.

Objectives: Test the feasibility, and use these results to increase the accuracy, of machine learning algorithms incorporated into an open-source distributed database to use extant gray whale (*E. robustus*) mark-recapture photo data to better understand the distribution, status, and sensitivities of this species.

Methods: Phase 1: A Wild Me Computer Vision Engineer will evaluate the HotSpotter algorithm performance on matching lateral gray whales (e.g., top-1 % correct match, top-5%, etc.). Annotations will be compared to determine the % accuracy when used to compare the same individuals' photos against a catalog of other individuals. Phase II: A Wild Me Computer Vision Engineer will develop an ensemble technical foundation in Flukebook that allows multiple algorithm ID predictions to be combined into a single suggestion algorithm. Additionally, a gray whale-specific ensemble algorithm will be created.

Specific Research Question(s):

1. Can the HotSpotter algorithm be effectively used to match lateral gray whale photographs?
2. Are ensemble algorithm predictions more effective than individual algorithm predictions?
    a. If so, can a gray whale-specific ensemble algorithm be developed?

Current Status: Phase I was successfully completed and the final report (Holmberg et al. 2021) was published in August 2021; the results informed the development of Phase II. Phase II was awarded on August 13, 2021, and planning is underway.

Publications Completed:

Holmberg JA, Parham JR, Blount A. 2021. Feasibility Analysis: Using Artificial Intelligence to Match Photographed Lateral Ridges of Gray Whales. Camarillo (CA): US Department of the Interior, Bureau of Ocean Energy Management, Pacific OCS Region. OCS Study BOEM 2021-059. 29 p. https://www.boem.gov/BOEM-2021-059

Affiliated WWW Sites: None

References:

Calambokidis J, Laake JL, Klimek A. 2010. Abundance and population structure of seasonal gray whales in the Pacific Northwest, 1998-2008. IWC Scientific Committee Report SC/62/BRG32. 50 p.

Frasier TR, Koroscil SM, White BN, Darling JD. 2011. Assessment of population substructure in relation to summer feeding ground use in the eastern North Pacific gray whale. Endangered Species Research. 14:39-48.

IUCN (International Union for Conservation of Nature). 2009. Report of the Western Gray Whale Advisory Panel at its Sixth Meeting. WGWAP-6. April 2009, Geneva, Switzerland. 46 p.

Lagerquist BA, Palacios DM, Winsor MH, Irvine LM, Follett TN, Mate BR. 2018. Feeding Home Ranges of Pacific Coast Feeding Group Gray Whales. The Journal of Wildlife Management. DOI: 10.1002/jwmg.21642

Lang AR, Calambokidis J, Scordino J, Pease VL, Klimek A, Burkanov VN, Gearin P, Litovka DI, Robertson KM, Mate BR, Jacobsen JK, Taylor BL. 2014. Assessment of genetic structure among eastern North Pacific gray whales on their feeding grounds. Marine Mammal Science. 30:4(1473-1493. DOI: 10.1111/mms.12129

Mate BM, Ilyashenko VY, Bradford AL, Vertyankin VV, Tsidulko GA, Rozhnov VV, Irvine LM. 2015. Critically endangered western gray whales migrate to the eastern North Pacific. Biology Letters. 11:1-4. 20150071. https://royalsocietypublishing.org/doi/10.1098/rsbl.2015.0071